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(54) **CLAMPING DEVICE HAVING RING SHAPE WITH HYDRAULICALLY DOWN FORCE CLAMPING MEANS**

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USPC 269/27, 22, 30, 33; 279/141
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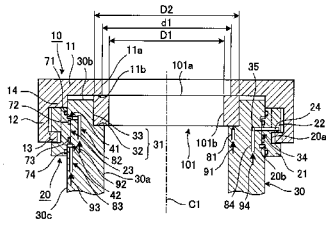
(57) **ABSTRACT**

Provided is a clamping device having improved safety and an improved clamping force for clamping a work to an attaching table, said work having the inner circumferential surface thereof to be processed. The clamping device clamps a work (**101**) disposed on the reference surface (**32**) of an attaching table (**30**). The clamping device is provided with: a board-like fixing member (**10**), which has formed therein a hole (**11***a*) that is larger than the inner diameter (D**1**) of the work (**101**) but smaller than the outer diameter (D**2**) of the work, and which is in surface-contact with the end surface (**101***a*) of the work (**101**) disposed on the reference surface (**32**) of the attaching table (**30**); and a pressing force applicator (**20**), which has a cylindrical shape that surrounds the attaching table (**30**), and which applies a pressing force toward the end surface (**101***a*) of the work (**101**) with respect to the fixing member (**10**).

4 Claims, 4 Drawing Sheets



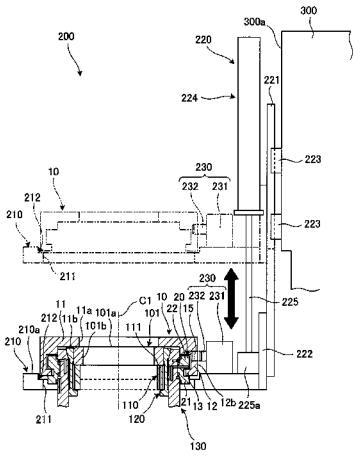


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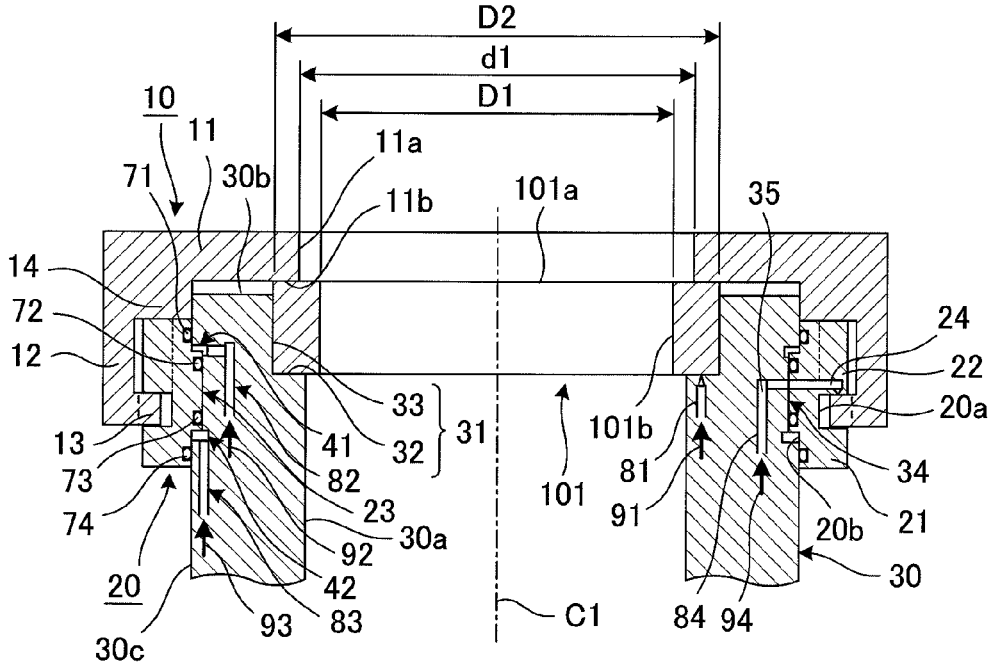
Fig. 1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d1
D1
10
11
11a
71
30b
11b
101a
35
14
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12
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20a
33
31
13
41
32
101b
34
73
82
81
101
74
23
91
21
30a
20b
92
20
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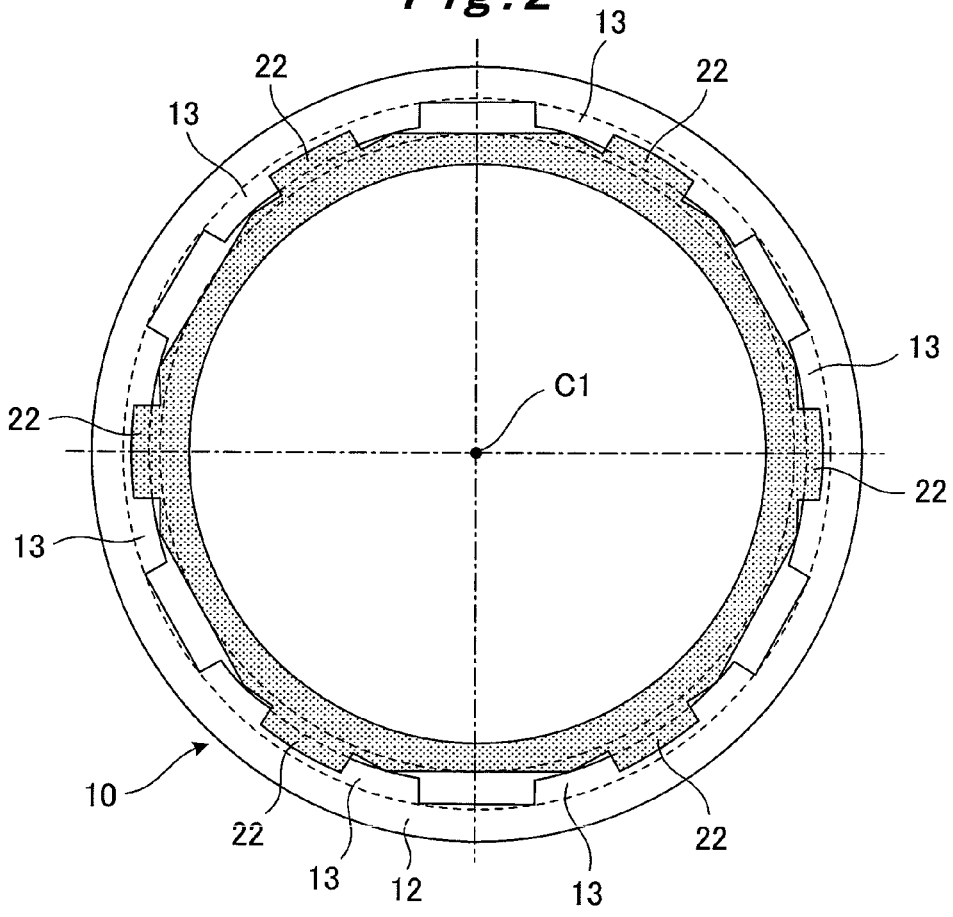
30
93
83
C1
84
94
30c

Fig. 2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22
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13
C1
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10
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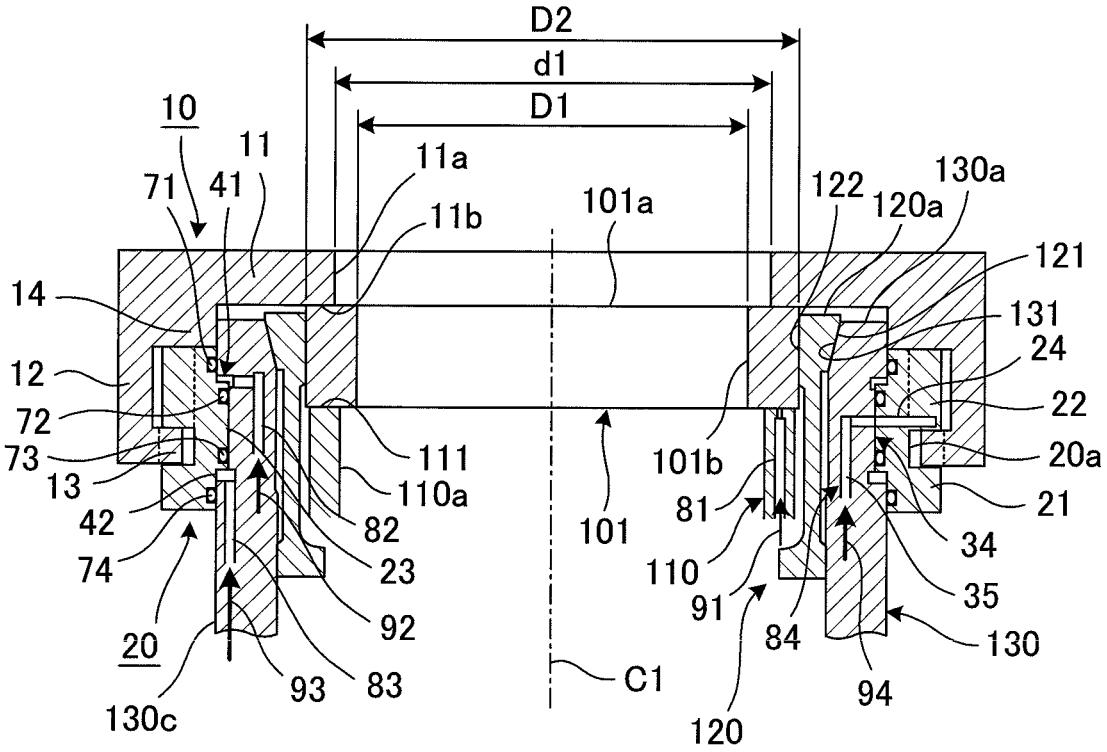
13
12
13

Fig. 3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121
14
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24
72
22
73
111
101b
20a
13
110a
81
21
42
82
101
34
74
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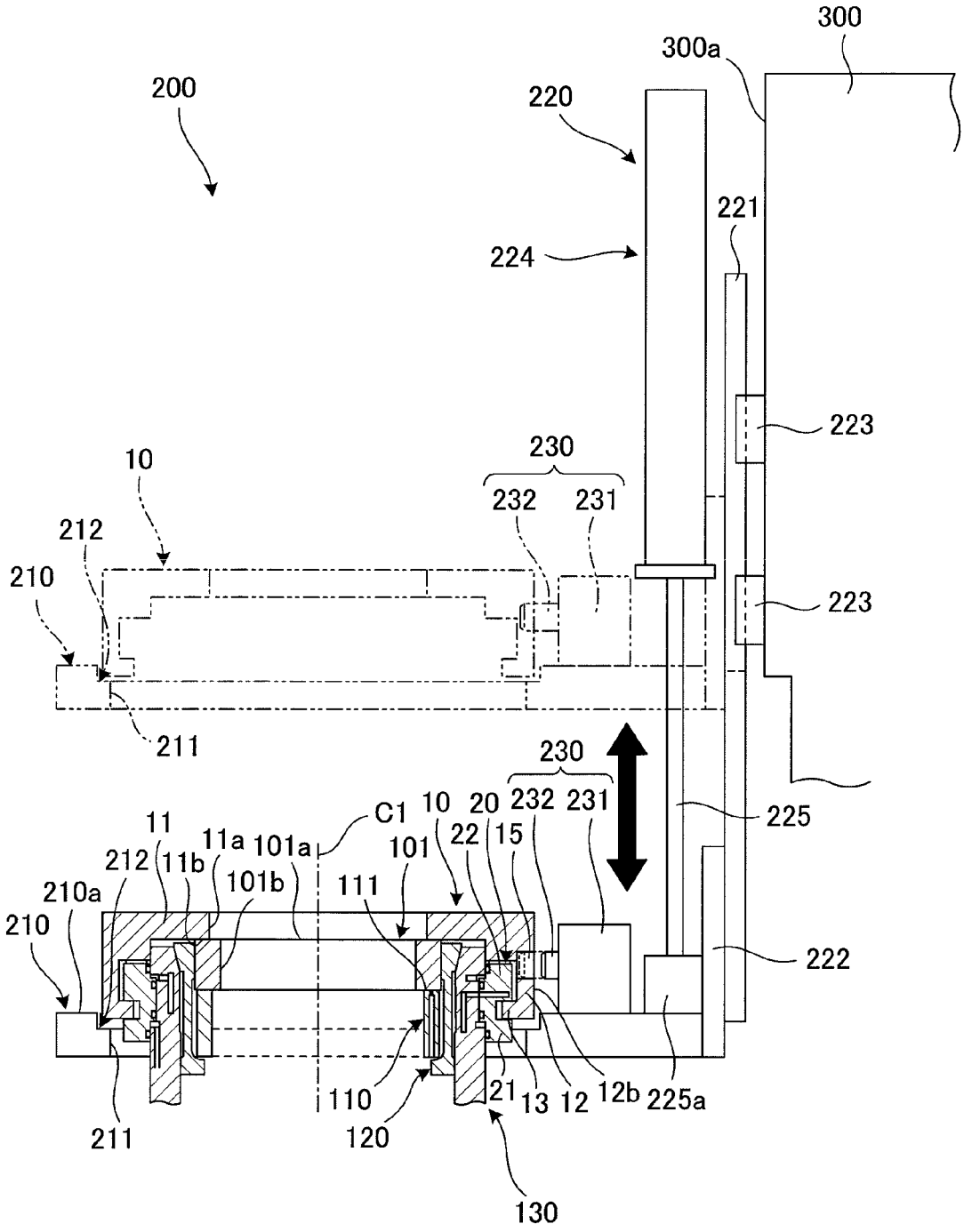
35
91
92
84
130
20
93
83
C1
94
130c
120

Fig. 4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231
11
11a
101a
101
22
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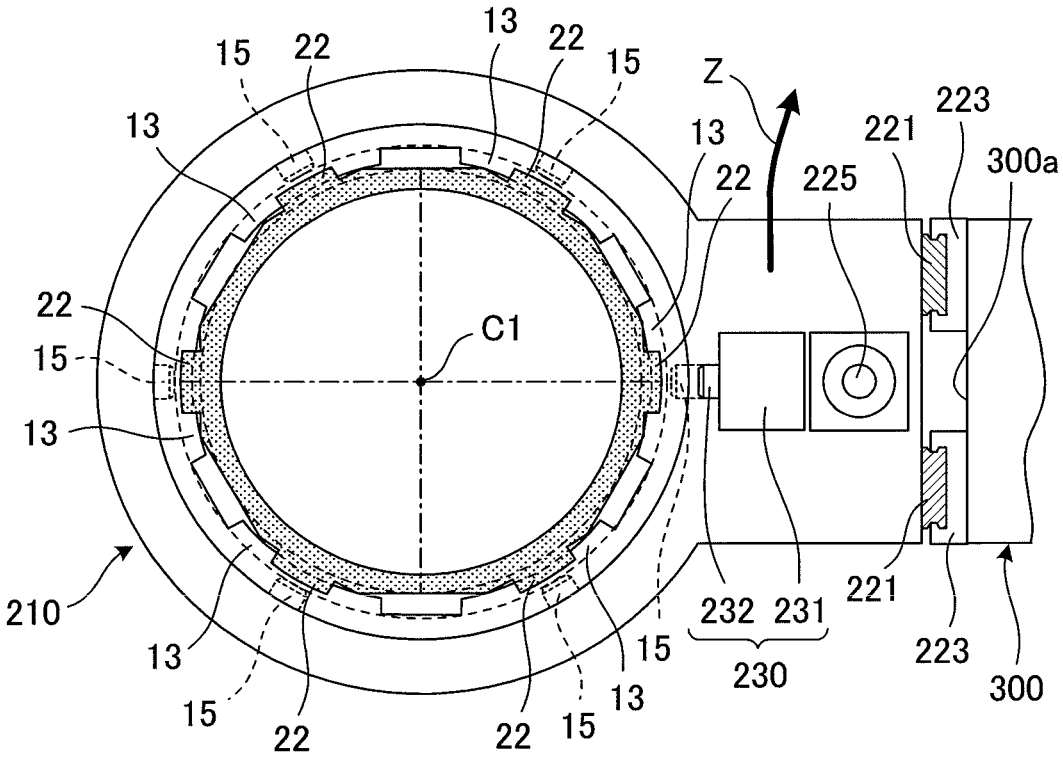
12
12b
225a
211
120
130

Fig. 5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22
15
13
15
232
231
230
221
223
300

CLAMPING DEVICE HAVING RING SHAPE WITH HYDRAULICALLY DOWN FORCE CLAMPING MEANS

TECHNICAL FIELD

The present invention relates to a clamping device configured to clamp a workpiece to a mount table, and particularly to a clamping device suitable for use in finishing an inner circumferential surface of a workpiece by grinding.

BACKGROUND ART

To improve gear accuracy, an internal-gear workpiece having undergone a heat treatment is secured to a mount table, and the tooth surface of the internal-gear workpiece in this state is finished by grinding. Examples of a method for securing the internal-gear workpiece include a method in which an outer circumferential surface of the internal-gear workpiece is clamped and a method in which an end surface of the internal-gear workpiece is clamped (see, for example, Patent Document 1).

As the method in which the outer circumferential surface of the internal-gear workpiece is clamped, there is a method using a collet or multiple claw portions. In the method using a collet, a workpiece is placed on an upper surface of a mount table, and a collet is arranged to hold the outer circumferential surfaces of the workpiece and the mount table. Then, the collet is drawn downward to forcibly reduce the diameter of the collet near the upper end thereof. Thus, the workpiece is held at the entire circumference of its outer circumferential surface, and is secured to the mount table. In the method using multiple claw portions, a workpiece is placed on an upper surface of a mount table, and the multiple claw portions are pressed against an outer circumferential surface of the workpiece. Thus, the workpiece is held at its outer circumferential surface, and is secured to the mount table.

Examples of the method in which the end surface of an internal-gear workpiece is clamped include a method using fingers or arms. In the method using fingers, a workpiece is placed on an upper surface of a mount table, and multiple fingers are turned vertically to press tip end portions of the fingers against an end surface of the workpiece. Thus, the workpiece is held at its end surface, and is secured to the mount table. In the method using arms, a workpiece is placed on an upper surface of a mount table, and multiple arms are turned horizontally to place tip end portions of the arms on an end surface of the workpiece, and base end portions of the arms are drawn downward. Thus, the workpiece is held at its end surface, and is secured to the mount table.

PRIOR ART DOCUMENT

Patent Document

Patent Document 1: Japanese Examined Utility Model Registration Application Publication No. Hei 7-27056 (see, for example, [FIG. 1] and the like)

SUMMARY OF THE INVENTION

Problems to be Solved by the Invention

High-speed spinning of a mount table (workpiece) is under consideration in view of improving work efficiency in grind finishing. However, in the above-described methods of clamping the outer circumferential surface of the workpiece, a centrifugal force acts on the jig (the collet or multiple claw portions) to weaken the binding force on the workpiece. Accordingly, the speed of spinning the mount table (workpiece) cannot be increased more than a certain speed. In the method of clamping the end surface of the workpiece, the clamping force can be enhanced by increasing the number of fingers or arms, but the size of the device increases accordingly. Thus, there is a limit on the enhancement of the clamping force. Moreover, in the method of clamping the workpiece by use of the claw portions, fingers, or arms, if the jig (the claw portions, fingers, or arms) is broken or if a fixture securing the jig is loosened, the jig might possibly fly apart. For this reason, safety improvement is demanded.

Accordingly, the present invention has been made to solve the above problems, and has an objective to provide a clamping device in which a clamping force for clamping a workpiece, whose inner circumferential surface is to be machined, to a mount table is improved, and also safety is improved.

Means for Solving the Problems

To solve the above problems, a clamp device according to a first invention is a clamping device configured to clamp a workpiece placed on a reference surface of a mount table, characterized in that the clamping device includes: a plate-shaped securing member in which an opening portion is formed and which comes into surface contact with an end surface of the workpiece placed on the reference surface of the mount table, the opening portion being larger than an inner diameter of the workpiece and smaller than an outer diameter of the workpiece; and pressing-force applying means for applying a pressing force to the securing member toward the end surface of the workpiece, the pressing-force applying means having a cylinder shape surrounding the mount table.

To solve the above problems, a clamp device according to a second invention is the clamp device according to the first invention, characterized in that the pressing-force applying means is attached to the mount table.

To solve the above problems, a clamp device according to a third invention is the clamp device according to the second invention, characterized in that a hydraulic chamber capable of supplying and discharging hydraulic oil is formed by a protrusion portion provided to an inner circumferential portion of the pressing-force applying means and by a groove portion which is formed at an outer circumferential portion of the mount table and into which the protrusion portion of the pressing-force applying means is fitted.

To solve the above problems, a clamp device according to a fourth invention is the clamp device according to the third invention, characterized in that the securing member and the pressing-force applying means are coupled to each other by a bayonet mechanism.

To solve the above problems, a clamp device according to a fifth invention is the clamp device according to the fourth invention, characterized in that the clamping device further comprises transport means for transporting the securing member.

To solve the above problems, a clamp device according to a sixth invention is the clamp device according to the fifth invention, characterized in that the transport means includes a support table configured to support the securing member, and moving means for moving the support table upward and downward.

To solve the above problems, a clamp device according to a seventh invention is the clamp device according to the sixth invention, characterized in that the clamping device further

comprises phase adjustment means for adjusting a phase of the securing member, and the phase adjustment means includes a piston rod provided to the support table, capable of moving toward and away from the securing member, and capable of being fitted into a recessed portion formed at an outer circumferential surface of the securing member.

Effect of the Invention

The clamping device according to the present invention includes: the plate-shaped securing member in which the opening portion is formed, the opening portion being larger than the inner diameter of the workpiece and smaller than the outer diameter of the workpiece; and pressing-force applying means which has a cylinder shape surrounding the mount table and is configured to apply a pressing force to the securing member toward the end surface of the workpiece. During the work, a tool is inserted into the area surrounded by the inner circumferential portion of the workpiece. Accordingly, even when the securing member or the pressing-force applying means is broken, the securing member or the pressing-force applying means can be prevented from flying out. Thus, safety can be improved. In addition, the workpiece can be secured to the mount table by bringing the securing member into surface contact with the end surface of the workpiece. Accordingly, a clamping force for clamping the workpiece to the mount table can be improved, compared to the conventional clamping device configured to use claw portions to apply a pressing force toward the outer circumferential surface of a workpiece or the conventional clamping device configured to use fingers or arms to apply a pressing force toward the end surface of a workpiece.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a sectional view of a clamping device according to a first embodiment of the present invention.

FIG. **2** is a diagram illustrating how a securing member and a pressing-force applying instrument of the clamping device according to the first embodiment of the present invention are coupled to each other.

FIG. **3** is a sectional view of a clamping device according to a second embodiment of the present invention.

FIG. **4** is a side view of a clamping device according to a third embodiment of the present invention.

FIG. **5** is a top view of the clamping device according to the third embodiment of the present invention.

MODES FOR CARRYING OUT THE INVENTION

A clamping device according to the present invention is described specifically by use of embodiments.

First Embodiment

A clamping device according to a first embodiment of the present invention is described with reference to FIGS. **1** and **2**.

The clamping device according to this embodiment is attached to a mount table provided with a reference surface on which centering of a workpiece is performed. As shown in FIG. **1**, a mount table **30** has an opening portion **30***a* provided in its center, and a step portion **31** provided at an edge of the opening portion **30***a*. The step portion **31** includes a reference surface **32** and a side wall portion **33** being connected to an outer circumferential portion of the reference surface **32** and extending upward. An upper edge of the side wall portion **33** is connected to an upper surface portion **30***b* of the mount table **30**. The step portion **31** is formed into substantially the same size as outer diameter D**2** of a workpiece **101**, and centering of the workpiece **101** is performed by placing the workpiece **101** in the step portion **31**. In other words, the workpiece **101** is placed such that its center axis is coaxial with center axis C**1** of the mount table **30**. The side wall portion **33** is formed to have a smaller height than the workpiece **101**, and an end surface **101***a* of the workpiece **101** protrudes upward relative to the upper surface portion **30***b* of the mount table **30** when the workpiece **101** is placed in the step portion **31**. Note that gear teeth are formed at an inner circumferential surface **101***b* of the workpiece **101**.

The reference surface **32** of the step portion **31** is provided with first air supply passages **81**. The first air supply passages **81** communicate with the reference surface **32** so that the reference surface **32** of the step portion **31** can be supplied with air **91**. The multiple first air supply passages **81** are provided at circumferential positions. Whether the workpiece **101** is attached with a predetermined posture or not can be checked by measuring the pressure of air in the first air supply passages **81**. This suppresses decrease in the machining accuracy of the workpiece **101**.

A clamping device is a device configured to clamp the workpiece **101** placed on the reference surface **32** of the mount table **30**. The clamping device has: a securing member **10** having a surface contact portion **11***b* to be in surface contact with the end surface **101***a* of the workpiece **101** placed on the reference surface **32** of the mount table **30**; and a pressing-force applying instrument (pressing-force applying means) **20** configured to apply a pressing force to the securing member **10** toward the end surface **101***a* of the workpiece **101**.

The securing member **10** has a cylindrical shape with a bottom, and has a disk-shaped bottom plate portion **11** and a cylindrical portion **12** connected to an edge portion of the bottom plate portion **11**. An opening portion **11***a* is provided in the center of the bottom plate portion **11**. Diameter d**1** of the opening portion **11***a* is larger than inner diameter D**1** of the workpiece **101** and smaller than outer diameter D**2** of the workpiece **101**. A tip end portion (lower end portion) of the cylindrical portion **12** is provided with claw portions **13** protruding toward the center. The multiple claw portions **13** are provided at predetermined intervals in the circumferential direction of the cylindrical portion **12**. A protrusion portion **14** protruding toward the center is formed over the entire circumference of a base end portion of the cylindrical portion **12**. As shown in FIGS. **1** and **2**, the multiple claw portions **13** and the protrusion portion **14** as well as first and second outer protrusion portions **21**, **22** of the pressing-force applying instrument **20** to be described later form a bayonet mechanism, and can be coupled to each other. Thus, the pressing-force applying instrument **20** and the securing member **10** can be moved upward or downward together. When the pressing-force applying instrument **20** moves downward, the securing member **10** also moves downward, bringing the tip end portion (surface contact portion) **11***b* of the bottom plate portion **11** of the securing member **10** into surface contact with the end surface **101***a* of the workpiece **101**. Thereby, a pressing force is applied to the workpiece **101** toward the mount table **30**. When the pressing-force applying instrument **20** moves upward, the securing member **10** also moves upward, making the workpiece **101** unclamped from the mount table **30**.

The pressing-force applying instrument **20** has a cylindrical shape, and is attached to an outer circumferential portion **30***c* of the mount table **30** at a position near the upper surface portion **30***b* in such a manner as to be movable upward and downward. A first outer protrusion portion **21** protruding

radially is formed over the entire circumference of a portion below an outer circumferential portion **20***a* of the pressing-force applying instrument **20**. Multiple second outer protrusion portions **22** protruding radially are formed at circumferential positions above the outer circumferential portion **20***a* of the pressing-force applying instrument **20**. Thus, the securing member **10** and the pressing-force applying instrument **20** can be coupled to each other by the bayonet mechanism, and the securing member **10** can be attached to pressing-force applying instrument **20** easily.

An inner protrusion portion **23** is formed at an inner circumferential portion **20***b* of the pressing-force applying instrument **20**. The inner protrusion portion **23** protrudes toward the center (toward the mount table **30**) and can be fitted into a groove portion **34** formed at the outer circumferential portion **30***c* of the mount table **30**. The groove portion **34** of the mount table **30** and the inner protrusion portion **23** of the pressing-force applying instrument **20** form a first hydraulic chamber **41** and a second hydraulic chamber **42**. A first hydraulic passage **82** communicating with the first hydraulic chamber **41** is formed in the mount table **30**. The pressing-force applying instrument **20** is biased downward when hydraulic oil **92** is supplied to the first hydraulic chamber **41** through the first hydraulic passage **82** by a pump (not shown). Thereby, the securing member **10** is pulled downward, and the surface contact portion **11***b* of the securing member **10** thus biases the end surface **101***a* of the workpiece **101** toward the reference surface **32** of the mount table **30**. Thus, the workpiece **101** is secured to the reference surface **32** of the mount table **30**.

A second hydraulic passage **83** communicating with the second hydraulic chamber **42** is formed in the mount table **30**. The pressing-force applying instrument **20** is biased upward when hydraulic oil **93** is supplied to the second hydraulic chamber **42** through the second hydraulic passage **83** by a pump (not shown). Thereby, the securing member **10** is pushed upward, and the force by the surface contact portion **11***b* of the securing member **10** pressing the end surface **101***a* of the workpiece **101** toward the reference surface **32** of the mount table **30** is released.

Note that sealing rubbers **71**, **72** are arranged in the inner circumferential portion **20***b* of the pressing-force applying instrument **20** on both sides of the first hydraulic chamber **41**, respectively, in order to prevent hydraulic oil **92** from leaking from the first hydraulic chamber **41**. Moreover, sealing rubbers **73**, **74** are arranged in the inner circumferential portion **20***b* of the pressing-force applying instrument **20** on both sides of the second hydraulic chamber **42**, respectively, in order to prevent hydraulic oil **93** from leaking from the second hydraulic chamber **42**.

Second air supply passages **84** are provided through the mount table **30** and the pressing-force applying instrument **20**. The second air supply passages **84** each include a communication hole **35** formed in the mount table **30** and an air supply hole **24** formed in the pressing-force applying instrument **20**. Note that the communication hole **35** is formed with a larger diameter than the air supply hole **24**. For this reason, even when the pressing-force applying instrument **20** moves upward and downward, the communication hole **35** and the air supply hole **24** still communicate with each other, so that air **94** can be supplied to the air supply hole **24** through the communication hole **35**. A tip end portion of the air supply hole **24** faces a lower surface portion of the second outer protrusion portion **22**. The multiple second air supply passages **84** are provided at circumferential positions in the pressing-force applying instrument **20**. Whether the workpiece **101** is attached with a predetermined posture or not can be checked by measuring the air pressure in the second air supply passages **84**. Thereby, the securing member **10** can be held securely.

Subsequently, a description is given of operations of the clamping device having the above configuration, or specifically, operations for clamping the workpiece **101** to the mount table **30** and operations for unclamping the workpiece **101**.

First, to clamp the workpiece **101** to the mount table **30**, the workpiece **101** is placed on the reference surface **32** of the step portion **31** of the mount table **30**. Next, the securing member **10** is attached to the pressing-force applying instrument **20**. After the securing member **10** is attached to the pressing-force applying instrument **20**, hydraulic oil **92** is supplied to the first hydraulic chamber **41** through the first hydraulic passage **82** by a pump. Thereby, the pressing-force applying instrument **20** is biased downward, and the securing member **10** is pulled downward. As a result, the surface contact portion **11***b* of the securing member **10** biases the end surface **101***a* of the workpiece **101** toward the reference surface **32** of the mount table **30**. Thus, the workpiece **101** is secured to the reference surface **32** of the mount table **30**. Here, the posture of the workpiece **101** can be checked by measuring the air pressure in the first air supply passage **81**. In addition, the posture of the securing member **10** can be checked by measuring the air pressure in the second air supply passage **84**. After confirming that the workpiece **101** and the securing member **10** are arranged with their predetermined postures, a tool (not shown) is inserted into an area surrounded by the inner circumferential surface **101***b* of the workpiece **101**, and the inner circumferential surface **101***b* of the workpiece **101** is finished.

On the other hand, to unclamp the workpiece **101**, the supply of hydraulic oil **92** to the first hydraulic chamber **41** by the pump is stopped, and hydraulic oil **93** is supplied to the second hydraulic chamber **42** through the second hydraulic passage **83** by a pump. Thereby, the pressing-force applying instrument **20** is biased upward, and the securing member **10** is pushed upward. As a result, the force by the surface contact portion **11***b* of the securing member **10** pressing the end surface **101***a* of the workpiece **101** toward the reference surface **32** of the mount table **30** is released. Consequently, the workpiece **101** is now merely placed on the reference surface **32** of the mount table **30**. In other words, the workpiece **101** is unclamped. In this state, the mount table **30** is turned to detach the securing member **10** from the pressing-force applying instrument **20**, and the workpiece **101** is taken out from the step portion **31** of the mount table **30**.

As described, in the clamping device according to this embodiment, the securing member **10** has: the opening portion **11***a* with diameter d1 which is larger than inner diameter D1 of the workpiece **101** and smaller than outer diameter D2 of the workpiece **101**; and the surface contact portion **11***b* to be in surface contact with the end surface **101***a* of the workpiece **101**. During the work, a tool is inserted into the area surrounded by the inner circumferential surface **101***b* of the workpiece **101**. Accordingly, even when the pressing-force applying instrument **20** is broken, the securing member **10** is prevented from flying out. This accomplishes safety improvement. Moreover, since the securing member **10** can apply a pressing force to the entire circumference of the end surface **101***a* of the workpiece **101** toward the mount table **30**, a clamping force for clamping the workpiece **101** to the mount table **30** can be improved, compared to the conventional clamping device configured to use claw portions to apply a pressing force toward the outer circumferential surface of a

workpiece or the conventional clamping device configured to use fingers or arms to apply a pressing force toward the end surface of a workpiece.

Second Embodiment

With reference to FIG. **3**, a description is given of a clamping device according to a second embodiment of the present invention. In this embodiment, centering of the workpiece is performed using a guide member and a collet instead of the step portion of the mount table. In this embodiment, the mount table of the clamping device according to the first embodiment described above is alternatively formed by a mount table, a collet, and a guide member, and other instruments are the same as those in the first embodiment. In this embodiment, instruments that are the same as those of the clamping device according to the first embodiment are given the same reference numerals, and are not described again.

In the clamping device according to this embodiment, the workpiece **101** is placed on a reference surface **111** of a mount table **110**, as shown in FIG. **3**. An opening portion **110***a* is provided in the center of the mount table **110**. The clamping device includes a collet **120** and a guide member **130** which are configured to perform centering of the workpiece **101**. The groove portion **34** is formed at an outer circumferential portion **130***c* of the guide member **130**, and the inner protrusion portion **23** of the pressing-force applying instrument **20** is fitted into this groove portion **34**. Like the mount table **30** of the clamping device according to the first embodiment described above, the first and second hydraulic chambers **41**, **42** are formed. The first and second hydraulic passages **82**, **83** are formed to communicate with the first and second hydraulic chambers **41**, **42**, respectively. Hydraulic oil **92**, **93** can be supplied to the first and second hydraulic chambers **41**, **42**, respectively. The pressing-force applying instrument **20** and the securing member **10** can be coupled to each other using a bayonet mechanism. Thereby, the pressing-force applying instrument **20** and the securing member **10** can move upward and downward together.

An inclination portion **131** increasing in diameter upward is formed at an inner circumferential portion of the guide member **130** at a position near an upper end portion **130***a*. The collet **120** is placed between the mount table **110** and the guide member **130**. The collet **120** can be drawn downward in FIG. **3** by a drawing mechanism (not shown). A tapered portion **121** increasing in diameter upward is formed at an outer circumferential portion of the collet **120** at a position near an upper end portion **120***a*. A hold portion **122** configured to hold the workpiece **101** placed on the reference surface **111** of the mount table **110** is formed at an inner circumferential portion of the collet **120** at a position near the upper end portion **120***a*. Thus, when the collet **120** placed between the mount table **110** and the guide member **130** is drawn downward with the workpiece **111** being placed on the reference surface **111** of the mount table **110**, a portion near the upper end portion **120***a* of the collet **120** is forcibly decreased in diameter. Thereby, centering of the workpiece **101** placed on the reference surface **111** of the mount table **110** is performed. By pushing the collet **120** upward, the force decreasing the diameter of the portion near the upper end portion **120***a* of the collet **120** is released.

Subsequently, descriptions are given of operations of the clamping device having the above-described configuration, or specifically, operations for clamping the workpiece **101** to the mount table **110** and operations for unclamping the workpiece **101**.

First, to clamp the workpiece **101**, the workpiece **101** is placed on the reference surface **111** of the mount table **110**. Then, the collet **120** is placed between the mount table **110** and the guide member **130**, and is drawn downward in FIG. **3**. Centering of the workpiece **101** is thus performed. The securing member **10** is attached to the pressing-force applying instrument **20**. Next, hydraulic oil **92** is supplied to the first hydraulic chamber **41** through the first hydraulic passage **82** by a pump. Thereby, the pressing-force applying instrument **20** is biased downward, and the securing member **10** is pulled downward. As a result, the surface contact portion **11***b* of the securing member **10** biases the end surface **101***a* of the workpiece **101** toward the reference surface **111** of the mount table **110**. Thus, the workpiece **101** is secured to the reference surface **111** of the mount table **110**. In this state, a tool (not shown) is inserted into an area surrounded by the inner circumferential surface **101***b* of the workpiece **101**, and the inner circumferential surface **101***b* of the workpiece **101** is finished.

On the other hand, to unclamp the workpiece **101**, the supply of hydraulic oil **92** to the first hydraulic chamber **41** by the pump is stopped, and hydraulic oil **93** is supplied to the second hydraulic chamber **42** through the second hydraulic passage **83** by a pump. Thereby, the pressing-force applying instrument **20** is biased upward, and the securing member **10** is pushed upward. As a result, the force by the surface contact portion **11***b* of the securing member **10** pressing the end surface **101***a* of the workpiece **101** toward the reference surface **111** of the mount table **110** is released. Consequently, the workpiece **101** is now merely placed on the reference surface **111** of the mount table **110**. In other words, the workpiece **101** is unclamped. In this state, the mount table **110** is turned to detach the securing member **10** from the pressing-force applying instrument **20**, and the workpiece **101** is taken out from the mount table **110**.

Thus, according to the clamping device of this embodiment, like the clamping device according to the first embodiment, a clamping force for clamping the workpiece **101** to the mount table **110** can be improved, compared to the conventional clamping device configured to use claw portions to apply a pressing force toward the outer circumferential surface of a workpiece or the conventional clamping device configured to use fingers or arms to apply a pressing force toward the end surface of a workpiece. Moreover, safety improvement can be accomplished.

Third Embodiment

A clamping device according to a third embodiment of the present invention is described with reference to FIGS. **4** and **5**. In this embodiment, a transport device configured to transport the securing member is further provided to the clamping device according to the second embodiment described above. In this embodiment, instruments that are the same as those of the clamping device according to the second embodiment are given the same reference numerals, and are not described again.

As shown in FIGS. **4** and **5**, the clamping device according to this embodiment further includes a transport device **200** configured to transport the securing member **10**. The transport device **200** has a support table **210** configured to support the securing member **10** and a moving mechanism (moving means) **220** configured to move the support table **210** upward and downward.

The support table **210** is provided with an opening portion **211** and a step portion **212** along the opening portion **211**. The opening portion **211** of the support table **210** is formed to allow insertion of the mount table **110**, the collet **120**, the

guide member **130**, and the pressing-force applying instrument **20**. The step portion **212** is formed to allow the lower end portion of the securing member **10** to be fitted thereinto. Thus, the securing member **10** can be supported at a predetermined position on an upper surface portion **210***a* of the support table **210**.

A phase adjustment mechanism (phase adjustment means) **230** configured to adjust the phase of the securing member **10** is provided to the support table **210** at a position adjacent to the step portion **212**. The phase adjustment mechanism **230** includes a cylinder **231** and a piston rod **232** movable toward and away from the securing member **10**. A tip end portion of the piston rod **232** is formed into a shape that can be fitted into a recessed portion **15** formed at an outer circumferential portion **12***b* of the securing member **10**. Thus, the phase of the securing member **10** can be adjusted.

The moving mechanism **220** is provided to a front surface portion **300***a* of a column **300** of a machine tool for machining the workpiece **101**. The moving mechanism **220** has: rails **221** extending vertically; brackets **222** configured to secure lower end portions of the rails **221** to a base end portion of the support table **210**; sliding portions **223**, **223** which are provided to the front surface portion **300***a* of the column **300** and in which the respective rails **221** are slidable; and a cylinder **224**. A piston rod **225** is provided to the cylinder **224** in such a manner as to be capable of advancing and retreating (moving upward and downward). A tip end portion **225***a* of the piston rod **225** is secured to the support table. The support table **210** moves upward and downward along with the advancing and retreating motion of the piston rod **225**. The cylinder **224** is secured to the front surface portion **300***a* of the column **300** of the machine tool by means of a securing instrument (not shown).

Subsequently, operations for transporting the securing member **10** by the clamping device having the above-described configuration are described.

The workpiece **101** is placed on the reference surface **111** of the mount table **110**, and the collet **120** is drawn downward. In other words, the workpiece **101** is placed on the reference surface **111** of the mount table **110** with centering of the workpiece **101** being completed. Subsequently, the column **300** is turned to locate the moving mechanism **220** at a position facing the workpiece **101**. That is, the securing member **10** is located above the workpiece **101**. Next, the support table **210** is moved downward along the rails **221** by extending the piston rod **225**. Then, the mount table **110** is turned to couple the securing member **10** to the pressing-force applying instrument **20**. Next, with the piston rod **232** of the phase adjustment mechanism **230** being retracted, and with the piston rod **225** of the moving mechanism **220** being further extended, the support table **210** is moved further downward. In this state, a tool is placed in an area surrounded by the inner circumferential surface **101***a* of the workpiece **101**, and the inner circumferential surface **101***a* of the workpiece **101** is finished by grinding and the like.

Next, a description is given of operations for withdrawing the securing member **10** after finishing the inner circumferential surface of the workpiece.

First, the tool is moved upward from the area surrounded by the inner circumferential surface **101***a* of the workpiece **101**, so as to withdraw the tool to a position away from the upper area of the workpiece **101**. Next, the piston rod **225** of the moving mechanism **220** is retracted to move the support table **210** upward along the rails **221**. The step portion **212** of the support table **210** is placed near the lower end portion of the securing member **10**. Then, the mount table **110** is turned as necessary. Next, the piston rod **232** of the phase adjustment mechanism **230** is extended to insert the tip end portion of the piston rod **232** to the recessed portion **15** of the securing member **10**. After that, the mount table **110** is turned to release the coupling between the securing member **10** and the pressing-force applying instrument **20**. Then, the piston rod **225** of the moving mechanism **220** is retracted to move the support table **210** and the securing member **10** upward along the rails **221**. The column **300** is turned as necessary. Thus, the securing member **10** is placed at a position away from the position above the workpiece **101**.

Thus, according to the clamping device of this embodiment, like the second embodiment described above, a clamping force for clamping the workpiece **101** to the mount table **110** can be improved, compared to the conventional clamping device configured to use claw portions to apply a pressing force toward the outer circumferential surface of a workpiece or the conventional clamping device configured to use fingers or arms to apply a pressing force toward the end surface of a workpiece. Moreover, safety improvement can be accomplished.

Further, since the transport device **200** is included, the securing member **10** can be transported. Accordingly, the securing member **10** can be replaced easily, and the workpiece **101** can be withdrawn. Thus, further safety improvement can be accomplished.

Since the transport device **200** is configured with the support table **210** and the moving mechanism **220**, the device is simple as a whole. Thus, increase in facility costs can be suppressed.

By further including the phase adjustment mechanism **230**, phase alignment between the securing member **10** and the pressing-force applying instrument **20** can be easily done. Thereby, the work can be performed with high efficiency.

Although the present invention is applied to a clamping device configured to perform centering of the workpiece **101** by using the collet **120** in the above description, the present invention is also applicable to a clamping device configured to perform the workpiece centering by using the reference surface of the step portion provided to the mount table.

INDUSTRIAL APPLICABILITY

The clamping device according to the present invention can improve a clamping force for clamping a workpiece, whose inner circumferential surface is to be machined, to a mount table, and can also improve safety; therefore, the clamping device is beneficial in the machine tool industry and the like.

EXPLANATION OF REFERENCE NUMERALS

10 SECURING MEMBER
11 BOTTOM PLATE PORTION
12 CYLINDER PORTION
13 CLAW PORTION
14 PROTRUSION PORTION
15 RECESSED PORTION
20 PRESSING-FORCE APPLYING INSTRUMENT
21 FIRST OUTER PROTRUSION PORTION
22 SECOND OUTER PROTRUSION PORTION
23 INNER PROTRUSION PORTION
24 AIR SUPPLY OPENING
30 MOUNT TABLE
31 STEP PORTION
32 REFERENCE SURFACE
33 SIDE WALL PORTION
34 GROOVE PORTION
35 COMMUNICATION HOLE

41 FIRST HYDRAULIC CHAMBER
42 SECOND HYDRAULIC CHAMBER
71 TO **74** SEALING RUBBER
81 FIRST AIR SUPPLY PASSAGE
82 FIRST HYDRAULIC PASSAGE
83 SECOND HYDRAULIC PASSAGE
84 SECOND AIR SUPPLY PASSAGE
91, **94** AIR
92, **93** HYDRAULIC OIL
110 MOUNT TABLE
111 REFERENCE SURFACE
120 COLLET
121 TAPERED PORTION
130 GUIDE MEMBER
131 INCLINATION PORTION
200 TRANSPORT DEVICE
210 SUPPORT TABLE
211 OPENING PORTION
212 STEP PORTION
220 MOVING MECHANISM
221 RAIL
222 BRACKET
223 SLIDING PORTION
224 CYLINDER
225 PISTON ROD
230 PHASE ADJUSTMENT MECHANISM
231 CYLINDER
232 PISTON ROD
300 COLUMN OF MACHINE TOOL

The invention claimed is:

1. A clamping device configured to clamp a workpiece placed on a reference surface of a mount table, wherein the clamping device comprises:

a plate-shaped securing member including a plate portion in which an opening portion is formed and which comes into surface contact with an end surface of the workpiece placed on the reference surface of the mount table, the opening portion being larger than an inner diameter of the workpiece and smaller than an outer diameter of the workpiece; and

a cylinder-shaped pressing-force applying instrument configured to apply a pressing force to the securing member toward the end surface of the workpiece, the cylinder-shaped pressing-force applying instrument including a cylindrical portion surrounding the mount table,

the plate portion of the securing member is larger in diameter than the cylindrical portion of the pressing-force applying instrument,

the securing member includes

a cylindrical portion connected to an edge portion of the plate portion, and surrounding the cylindrical portion of the pressing-force applying instrument, and

a claw portion provided to an inner circumferential portion of the cylindrical portion of the securing member, and protruding toward a center of the cylindrical portion of the securing member,

the cylinder-shaped pressing-force applying instrument is attached to the mount table, and

a hydraulic chamber capable of supplying and discharging hydraulic oil is formed by a protrusion portion provided to an inner circumferential portion of the cylinder-shaped pressing-force applying instrument and by a groove portion which is formed at an outer circumferential portion of the mount table and into which the protrusion portion of the cylinder-shaped pressing-force applying instrument is fitted, and

the claw portion of the securing member, and an outer protrusion portion provided to an outer circumferential portion of the cylinder-shaped pressing-force applying instrument and protruding outward radially are connected together with a bayonet mechanism.

2. The clamping device according to claim **1**, wherein

the clamping device further comprises a transport device configured to transport the securing member.

3. The clamping device according to claim **2**, wherein

the transport device includes a support table configured to support the securing member, and a moving mechanism configured to move the support table upward and downward.

4. The clamping device according to claim **3**, wherein

the clamping device further comprises a phase adjustment mechanism configured to adjust a phase of the securing member, and

the phase adjustment mechanism includes a piston rod provided to the support table, capable of moving toward and away from the securing member, and capable of being fitted into a recessed portion formed at an outer circumferential surface of the securing member.

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